WE CLAIM:

1. A method of reducing incoherent signal power in an input optical signal containing a coherent component having a coherent signal power and a incoherent component having the incoherent signal power, the method comprising:

splitting the input optical signal into M path signals each having a respective coherent path component and a respective incoherent path component and wherein M satisfies $M \geq 2$;

applying a respective phase adjustment to each of the M path signals, the phase adjustments comprising at least one fine phase adjustment applied to at least one of the M path signals, wherein the phase adjustment are applied such that at a combination point, the coherent path components are combinable constructively and each incoherent path component is substantially uncorrelated with each other incoherent path component;

at the combination point, combining the M path signals to produce an output optical signal with an improved signal-to-noise ratio.

2. A method according to claim 1 wherein combining the M path signals to produce an output optical signal with an improved signal-to-noise ratio comprises coupling the M path signals together in a manner which produces the output optical signal containing most of the coherent signal power and containing a fraction of the incoherent signal power, with the remaining incoherent signal power being diverted to one or more subsidiary outputs.

3. A method according to claim 2 wherein the phase adjustments are achieved by employing an appropriately selected optical path length difference, ΔL_o, between any two consecutive path signals of the M path signals.

4. A method according to claim 3 wherein the optical path length difference, ΔL_o, between any two consecutive path signals of the M path signals substantially satisfies $\Delta L_o > L_c$, where L_c is the coherence length of the incoherent path components of the M path signals.

5. A method according to claim 3 wherein the optical path length difference, ΔL_o, between any two consecutive path signals of the M path signals substantially satisfies $\Delta L_o \leq \chi C/R$ wherein C is the speed of light in vacuum, R is a symbol rate of the input optical signal and χ is a symbol spread tolerance.

6. A method according to claim 1 adapted for single wavelength application, wherein the optical path length difference ΔL_o, between any two path signals of the M path signals results in a corresponding phase difference substantially satisfying $\delta = 2p\pi$, where $p = \pm 1, \pm 2, \ldots$ for a wavelength of interest.

7. A method according to claim 6 wherein a particular value of p is selected such that the corresponding optical path length difference, ΔL_o, between any two consecutive path signals of the M path signals substantially satisfies $\Delta L_o > L_c$ wherein L_c is the coherence length of the incoherent path components of the M path signals, and substantially satisfies $\Delta L_o \leq \chi C/R$ wherein C is the speed of light in vacuum, R is a

symbol rate of the input optical signal and χ is a symbol spread tolerance.

8. A method according to claim 1 adapted for multiple wavelength application with the input optical signal comprising a plurality of equally spaced channels with any two consecutive channels differing in frequency by, $\Delta f = f' - f$, wherein the optical path length difference, ΔL_o, substantially satisfies $\Delta L_o = KC/2\Delta f$, wherein $K = 1, 2, 3, \ldots$, and C is the speed of light in vacuum.

9. A method according to claim 8 wherein a particular value of K is selected such that the optical path length difference, ΔL_o, between any two path signals of the M path signals substantially satisfies $\Delta L_o > L_c$, where L_c is the coherence length of the incoherent path components of the M path signals, and substantially satisfies $\Delta L_o \le \chi C/R$ wherein C is the speed of light in vacuum, R is a symbol rate of the input optical signal and χ is a symbol spread tolerance.

10. A method according to claim 1 wherein M=2.

11. A method according to claim 1 wherein the splitting, the phase adjustment and the combining are performed N times wherein N satisfies $N \ge 2$.

12. A method according to claim 11 wherein the SNR is improved by a factor of M^N.

13. A method according to claim 1 wherein applying the respective phase adjustments comprises passing each of the path components through a respective transmission medium having a different respective optical path length.

14. A method according to claim 13 wherein the applying a fine phase adjustment to at least one path signal comprises applying a respective fine phase adjustment to at least M-1 of the M path signals.

15. A method according to claim 13 wherein the applying a respective phase adjustment to at least one path signal further comprises applying a respective fine phase adjustment each of the M path signals.

16. A method according to claim 2 further comprising measuring a power of at least one subsidiary output, and tuning at least one of the phase adjustments to minimize the power of the subsidiary output.

17. A method according to claim 1 wherein the splitting, combining and phase adjustment are performed with a Mach-Zehnder interferometer-based structure.

18. A method according to claim 1 wherein the splitting, combining and phase adjustment are performed with a Michelson interferometer-based structure.

19. A noise reduction apparatus adapted to improve signal-to-noise ratio in an input optical signal containing a coherent component having a coherent signal power and an incoherent component having an incoherent signal power, the apparatus comprising:

an input optical splitter, M optical transmission paths, and an output optical coupler, where M >=2;

wherein the input optical splitter is adapted to split the input optical signal into M path signals each having a respective coherent path component and a respective incoherent path component, wherein each one of the M path signals propagates through a respective one of the M optical

transmission paths resulting in a respective phase adjustment to the respective path signal; and

a fine phase adjustment device in at least one of the optical transmission paths adapted to apply a fine phase adjustment to a respective one of the M path signals;

wherein the phase adjustment applied by the transmission media in combination with the fine phase adjustment applied by the at least one fine phase adjustment device results in an optical path length difference, ΔL_o, between the two optical transmission media selected such that the incoherent path components are substantially not correlated with each other at the output optical coupler;

wherein the output optical coupler couples the path signals such that substantially all of the coherent signal power is produced at a main output, while the incoherent signal power is substantially divided between the main output and one or more subsidiary outputs.

20. A noise reduction apparatus according to claim 19 wherein each of the M optical transmission paths comprises a respective plurality of segments of optical transmission media with each segment having length and a respective index of refraction; wherein the fine phase adjustment device comprises means for adjusting at least one of the lengths and/or indices of refraction.

21. A noise reduction apparatus according to claim 20 wherein a phase adjustment device is provided in each optical transmission.

22. A noise reduction apparatus according to claim 19 wherein the optical transmission paths are optical waveguides.

23. A noise reduction apparatus according to claim 19 wherein the optical transmission paths are optical fibers.

24. A noise reduction apparatus according to claim 19 wherein M=2 and the input optical splitter is a 1x2 3-dB single-mode coupler.

25. A noise reduction apparatus according to claim 19 wherein M=2 and the input optical splitter is a 2x2 3-dB single-mode coupler.

26. A noise reduction apparatus according to claim 19 wherein M=2 and the output optical coupler is a 2x2 3-dB single-mode coupler.

27. A noise reduction apparatus according to claim 19 wherein said at least one fine phase adjustment device comprises a fine phase adjustment device in each of the M optical transmission media adapted to apply a respective phase adjustment to each of the M path signals.

28. A noise reduction apparatus according to claim 19 wherein the fine phase adjustment device comprises at least one heater adapted to introduce the fine phase adjustment by varying an index of refraction in at least part of the optical transmission path through the application of heat.

29. A noise reduction apparatus according to claim 19 wherein the at least one fine phase adjustment device comprises at least one device adapted to introduce a phase adjustment by applying a stretching force to at least part of one of the optical transmission path to change the physical length of the optical transmission path.

30. A noise reduction apparatus according to claim 29 wherein the at least one device is a piezo-electric device.

31. A noise reduction apparatus comprising a plurality of noise reduction apparatuses of claim 19 arranged in a serial configuration.

32. A noise reduction apparatus according to claim 31 further comprising a further noise reduction apparatus within at least one of the paths.

33. A noise reduction apparatus adapted to improve SNR in an input optical signal having a coherent component and an incoherent component, the apparatus comprising:

an optical coupler, two optical transmission media, and two optical reflectors;

wherein the optical coupler is adapted to split the input optical signal into two path signals each having a respective coherent path component and a respective incoherent path component, wherein each one of the two path signals propagates through a respective one of the two optical media to a respective one of the two optical reflectors where the respective path signal is reflected, and propagates back through the respective one of the two optical media to the optical coupler; and

at least one fine phase adjustment device adapted to apply a respective phase adjustment to at least one of the two path signals wherein the respective phase adjustment is applied in a manner that at the optical coupler the coherent path components are coupled substantially into a single output of the coupler, and the incoherent component is coupled to multiple outputs.

34. A noise reduction apparatus according to claim 33 wherein the SNR of the input signal is increased by a factor of 2.

35. A noise reduction apparatus according to claim 34 wherein the two reflectors are broadband fiber gratings.

36. A noise reduction apparatus according to claim 34 wherein the two reflectors are gold tip pig tail fiber reflectors.

37. A noise reduction apparatus according to claim 34 wherein the coupler is a 2x2 single-mode coupler.

38. A method of designing a noise reduction apparatus comprising:

determining a minimum allowable value of an optical path length difference, ΔL_o, between any two of M path signals such that incoherent path components of the any two of M path signals are substantially not correlated;

determining a maximum allowable value of the optical path length difference, ΔL_o, between any two of M path signals to satisfy a symbol spread tolerance;

selecting a phase difference between any two of M path signals in a manner that the optical path length difference, ΔL_o, associated with the phase difference is greater than the minimum allowable value and smaller than the maximum allowable value, and in a manner that the coherent path components of the M path signals are combined constructively at a combination point.

39. A method according to claim 38 wherein determining the minimum allowable value of the optical path length difference, ΔL_o, determining L_c, a coherence length of the incoherent path components of the M path signals.

40. A method according to claim 39 wherein determining the maximum allowable value of the optical path length difference, ΔL_o, comprises determining ΔL_o satisfying $\Delta L_o \le \chi C / R$ where C is the speed of light in vacuum, R is the symbol rate of an input optical signal and χ is a symbol spread tolerance.

41. A method according to claim 40 wherein the phase difference substantially satisfies $\delta = 2p\pi$, where $p = \pm 1, \pm 2, \ldots$ for a wavelength of interest, a particular value of p being selected such that the optical path length difference satisfies the minimum and maximum allowable values.

42. A method according to claim 40 further comprising:

identifying a set of frequencies having a frequency difference, Δf;

selecting the optical path length difference, ΔL_o, between any two of the M path signals which satisfies $\Delta L_o = KC/(2\Delta f)$ where C is the speed of light in vacuum and $K = 1, 2, 3, \ldots$, the particular value of K being selected such that the optical path length satisfies the minimum and maximum allowable values.

43. A noise reduction apparatus according to claim 18 further comprising a power detector connected to at least one subsidiary output of the noise reduction apparatus and to the controlling device, the power detector adapted to convert a subsidiary optical signal into a signal representative of the power of the subsidiary optical signal.

44. A noise reduction apparatus according to claim 43 wherein the controlling device is adapted to control at least one of the phase adjustments applied to the path signals as a function of the output of the power detector.

45. A noise reduction apparatus for improving the signal-to-noise ratio of an optical signal, comprising:

an input optical splitter adapted to split the optical signal into M path signals transmitted along respective M optical transmission paths, wherein M>=2;

a phase adjustment device in at least one of the M optical transmission paths adapted to apply a phase adjustment relative the M path signals; and

an output optical coupler adapted to combine the M path signals into an output optical signal having a portion of incoherent components of each of the M path signals substantially uncorrelated and having coherent components of each M path signal constructively combined.

46. A method of improving the signal-to-noise ratio of an optical signal comprising:

splitting the optical signal into a plurality of path signals, each path signal having a coherent path component and an incoherent path component;

adjusting the phase of at least one of the plurality of path signals such that, at a combination point, the coherent path components are combinable constructively and each incoherent path component is substantially uncorrelated with each other incoherent path component; and

combining the path signals at said combination point.

47. A noise reduction apparatus for an optical signal comprising:

an optical splitter for splitting an input optical signal having a coherent signal component and an incoherent

signal component into a plurality of path signals transmitted along a plurality of respective transmission paths;

a phase adjustment device associated with at least one of the plurality of transmission paths for applying a phase difference between the plurality of path signals; and

an optical coupler for combining the plurality of path signals into a main output optical signal and at least one subsidiary output optical signal, wherein the main output optical signal comprises substantially all of the coherent signal component and the subsidiary output signal comprises at least a portion of the incoherent signal component.